MDI TA

8,011A Voltmeter

TEMPORARY
OPERATING INSTRUCTIONS
MODEL 8011A VOLTMETER

NOTICE

These instructions are temporary and will be superceded by Operation and Maintenance Manual T. O. 33A1-12-301-1 and Illustrated Parts Breakdown T. O. 33A1-12-301-4.

in file 20

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John Fluke Mfg. Co., Inc.
Mountlake Terrace, Washington

SECTION IV

OPERATING INSTRUCTIONS

4-1 GENERAL

4-2 CONTROLS AND TERMINALS. The following descriptions are intended to familiarize the operator with the basic use of the controls and terminals of the 8011A. They are not intended as operating instructions. Refer to paragraph 4-3 before attempting to use the 8011A for any purpose. See figure 4-1 for the location of the controls and terminals.

a. POWER Switch. With the POWER switch on, the indicator light and one of the decimal lights adjacent to the Kelvin-Varley dials will be illuminated. This indicates that the primary circuit of the power transformer is closed.

b. RANGE Switch. The RANGE switch has four positions (0.5, 5, 50, and 500) and is used to select the range of the voltage to be measured.

c. OPERATE-CAL Switch. This switch has three positions: OPERATE, REF CAL, and ADJ CAL. When in the REF CAL position, the meter is removed from the VTVM circuit. When in the ADJ CAL position, the meter is placed in the circuit which compares a sample of the internal reference supply voltage with the Zener reference voltage. The switch is used in calibrating the instrument.

d. ADJ CAL Control. This control is used to set the reference supply to an exact 500 Volts by varying the potential on the grid of V3.

e. NULL Switch. The NULL switch determines whether the instrument is to be used as a VTVM or a differential voltmeter. In the VTVM position, the meter has a full-scale deflection equal to the value selected by the RANGE switch. The 10, 1, 0.1, and 0.01 Volt positions indicate the full-scale deflection of the meter when in one of the null ranges.

f. KELVIN-VARLEY Dials. These dials enable the operator to dial up any voltage from 0 to 500 Volts within the instrument. This voltage is used to buck out the unknown voltage being measured.

g. INPUT Terminals. Positive and negative terminals isolated from chassis ground, and a chassis ground terminal are provided. These terminals are located on 3/4 inch centers and will accommodate a banana plug.

4-3 PRELIMINARY ADJUSTMENT. To set up the instrment for operation, proceed as follows:

a. Connect instrument to 117 Volt, 60 cycle source.

b. Set RANGE switch to 500 position.

c. Set NULL switch to VTVM position.

d. Set all five KELVIN-VARLEY dials to zero.

e. Set CAL switch to REF.

f. Throw POWER switch to ON.

g. Allow the instrument to warm up for approximately 20 minutes.

h. Check to ensure that the meter is on zero. (If meter is not on zero, see Trouble Shooting instructions.)

i. Rotate and hold the CAL switch at the ADJ position with the left hand, then turn the ADJ CAL knob with the right hand until the meter again reads zero. The instrument is ready for use.

4-4 OPERATION

4-5 CONNECT TO INSTRUMENT UNDER TEST. As specified in paragraph 4-2, the 8011A is provided with a positive and negative input terminal and a chassis ground terminal. Under normal conditions it is only necessary to connect the positive and negative posts of the voltmeter to the positive and negative posts of the voltage to be measured.

CAUTION

Do not connect the positive binding post of the 8011A to the chassis ground post without checking the instrument under test to ensure that there is no conflict in grounding. Conflict in grounding will result in damage to the equipment.

4-6 MEASUREMENT OF POSTIVE DC VOLTAGES. To determine the value of positive DC voltages proceed as follows:

a. Set RANGE switch to 500 position, NULL switch to VTVM position, and connect the voltage to be measured to the plus and minus binding posts.

b. If the meter reads to the left, reverse the connection. If not, continue to step "c."

c. Set the RANGE switch to the lowest range which will give an on-scale reading, i.e. if the voltage is approximately 3.5 Volts set the RANGE switch to 5.

NOTE: With the NULL switch in the VTVM position, the 8011A functions as a conventional four range VTVM with 10 megohms input resistance on all ranges. Although it may be utilized for general purpose applications, it is intended in this instrument to give the approximate location of the unknown voltage in the 0 to 500 Volt spectrum.

d. Set the Kelvin-Varley dials to the approximate voltage indicated on the meter. For example, if the meter indicates the unknown voltage to be 3.5 Volts, set the A knob to 3, the B knob to 5, and C, D, and E knobs to 0. The decimal light between the A and B knobs will light if the RANGE switch is set to 5.

e. Turn the NULL switch to the 1 Volt position, and adjust the last four Kelvin-Varley dials (b, C, D, and E) for zero meter deflection.

NOTE: The 10 Volt NULL position may be skipped when measuring less than 10 Volts.

f. Turn the NULL switch to the 0.1 Volt position and adjust the last three Kelvin-Varley dials (C, D, and E) for zero meter deflection.

4-7 MEASURMENT OF NEGATIVE DC VOLTAGES. Voltages which are negative with respect to ground may be measured in the same manner as positive voltages. However, when the 8011A positive binding post is connected to the metal case--either at the posts themselves or at the source under measurement--and the negative side of the 8011A is connected to the "hot" side of the source, certain circuit conditions are changed and must be taken into consideration.

CAUTION

The 8011A has a 3-wire line cord with the third conductor (green) connected to the chassis. For personnel safety, this wire should be connected to a good earth ground. The positive binding post should not be connected to the chassis ground post before the

instrument under test has been checked to be sure that there is no conflict in the grounding of the circuit under test and the grounding of the 8011A.

First, a 1.0 mfd capacitor (C101) is connected directly across the source under measurement. In certain circuits this capacitance may affect the source EMF. If this capacitor were removed there would still be considerable capacity in the form of transformer winding capacitance and wiring strays between the 8011A input posts.

Second, a small 60 cycle signal appears between the 8011A input posts (across C101) when the plus post is connected to the metal case. This is caused by slightly unbalanced transformer high voltage winding-to core capacitances. Careful transformer design keeps this signal to less than 50 millivolts. Nevertheless, it may still affect the 8011A reading and/or the DC voltage being measured under the following conditions:

a. If the most sensitive null range (0.01 Volt) is being used, a fraction of a millivolt may get through to the chopper contacts and appear as a DC off-null reading. If the DC voltage under measurement is quite small, some inaccuracy may result.

b. If the source under measurement contains unilateral conducting elements--such as the diodes used in limiter circuits--together with high internal resistance, this small 60 cycle signal may be rectified by the diodes and appear across the source as DC which either adds to or subtracts from the true EMF of the source. The 8011A may read this false voltage. Therefore, if the source under measurement does contain diodes, choppers, or other unilateral circuit elements, some additonal filtering may be necessary to prevent this spurious 60 cycle signal from reaching the voltage source under measurement. A twin T filter is extremely effective and will reduce the signal to a few millivolts, which can behandled with a simple low-pass filter if still objectionable. One or more sections of a low-pass filter alone may also be used between the 8011A and the source. The twin T has the advantage of low series resistance. This is only important if off-null voltage excursions are being observed. Since the chopper input resistance is 10 megohms when in any but the 0.01 V range (6.875 megohms), series resistance of greater than 100 K may cause objectionable full-scale off-null error. At null the input resistance has no effect.

Third, connecting the positive binding post to the chassis leaves C101, a 1.0 mfd capacitor, connected across the input. With nothing connected to the input posts and the NULL switch in the more sensitive null ranges, the meter will move erratically as the settings of the five voltage dials are changed. This happens because C101 charges and discharges to the level set on the five voltage dials, through the input resistance of the VTVM channel (10 megohms

for the 10, 1 and 0.1 Volt ranges, and 6.875 megohms for the 0.01 Volt range). Since the entire change in voltage appears across the R in an RC circuit at the instant the change occurs, the meter needle will pin hard at the instant the voltage dials are changed (providing the change is greater than that required for full-scale meter deflection). Consequently, do not turn the voltage dials with the null switch in other than the VTVM position when the input is unterminated.

4-8 MEASURING VOLTAGE EXCURSIONS ABOUT A NOMINAL VALUE. To observe excursions of a voltage about a nominal value:

a. Determine nominal value by following the steps outlined in paragraph 4-6.

b. Observe the meter.

c. A right hand deflection of the meter needle indicates that the voltage under observation has increased by the amount indicated. A left hand deflection indicates that the voltage has decreased by the amount indicated.

4-9 USE AS A CONVENTIONAL VTVM. As specified in the "NOTE" in paragraph 4-6, the 8011A will function as a conventional VTVM when the NULL switch is in the VTVM position and the RANGE switch is in either the 500, 50, 5 or 0.5 position. In addition to these ranges, there are four other ranges available. These ranges are 10, 1, 0.1, and 0.01 Volts. The 10, 1, and 0.1 Volt ranges have an input resistance of 10 megohms. The 0.01 Volt range has 6.875 megohms input resistance. These ranges are accurate to 3% as are the 500, 50, 5, and 0.5 Volt ranges.

The use of the 500, 50, 5, and 0.5 Volt ranges is explained in paragraph 4-6. The 10, 1, 0.1, and 0.01 Volt ranges are used as follows:

a. Set all five voltage dials to zero.

b. Connect the voltage to be measured to the input binding posts.

c. Set the NULL switch to the desired range and read the voltage directly from the meter.

> NOTE: The RANGE switch is not used in this case and may be in any position.

4-10 MEASUREMENT OF HIGH RESISTANCES. The 8011A may be used to measure resistances between 1 megohm and 500,000 megohms. The following equation is used when determining these resistances:

$Rx = 10^7 \left(\frac{E}{Em} - 1\right)$ where:

Rx is the unknown resistance in megohms.
E is the voltage setting of the 5 voltage knobs.
Em is the meter reading on the appropriate scale (either 10-0-10 or 1-0-1) as determined by the NULL switch setting.
10^7 is the input resistance of the VTVM in the 10 and 1 Volt null ranges.

Consequently, to measure a high value resistance:

a. Set the RANGE switch to 500, and the NULL switch to either the 10 V or 1 V position.

b. Connect the unknown resistance between the plus and minus terminals.

NOTE: Use short, isolated leads as the 8011A will measure the leakage resistance of the insulation on long leads.

c. Adjust the five voltage controls to any desired value between 0.01 and 500 Volts or to any voltage which allows convenient reading of the meter, i.e. produces a reasonable, easily read meter deflection.

Example: The maximum resistance that can be read is approximately 500,000 megohms. If this resistance were connected to the input posts, the NULL switch to the 1 V position, and five voltage dials set to 499.910, the meter would read 0.01 Volts to the left of zero.

d. Read the meter, the voltage dials, and the NULL switch setting. Substitute these values in the above equation, and compute the resistance.

e. Resistances up to 5,000 megohms may be measured without using the formula:

(1) If the resistance is less than 500 megohms: Set the NULL switch to the 10 Volt position; adjust the five voltage knobs for full-scale meter deflection; and subtract 10 from the reading of the voltage dials. This gives the resistance in megohms.

(2) If the resistance is less than 5,000 megohms but more than 500 megohms: Set the NULL switch to the 1 Volt position; adjust the five voltage dials for full-scale meter deflection; subtract 1 from the reading of the voltage dials; and multiply the difference by 10. This gives the resistance in megohms.

4-11 STOPPING THE EQUIPMENT. To stop the equipment is in only necessary to turn off the POWER switch.

4-12 NOTES ON MEASURING DC VOLTAGES

4-13 GENERAL. Reference to Figure 1-2, 8011A Table of Specifications, will show the RANGE switch settings recommended for obtaining maximum accuracy. Since the accuracy is governed chiefly by the linearity of the Kelvin-Varley five-dial attenuator, and since the highest accuracy resistors in the attenuator are used in the A and B decades (all resistors matched to ±0.0025%) and the next highest accuracy in the C, D, and E decades (all resistors matched to ±0.025%), it is best to use these most accurate decades at all times.

Example: When measuring a voltage of 3.52 Volts, set the VOLTS RANGE switch to the 5 position and use all 5 knobs. Do not set the VOLTS RANGE switch to the 500 position and use only the last three knobs. Better absolute accuracy will be obtained when all five of the Kelvin-Varley dials are used.

Reference to the 8011A specifications will also indicate certain recommended NULL ranges to be used with each setting of the RANGE switch. The 0.01 Volt NULL range is not recommended for use in the 50 to 500 Volt range for three reasons. First, unless the voltage being measured is an even multiple of 0.01 Volt, it will be impossible to obtain a null because the last voltage dial is calibrated in 0.01 Volt steps when operating in the 500 Volt position of the RANGE switch and one step of this dial causes full-scale meter deflection with the NULL switch at 0.01 V. Second, it is unlikely that a large voltage (450 Volts, for example) will be stable to within 10 millivolts. Third, the 8011A will tend to meter the regulation of its own 500 Volt reference supply. The regulation of the reference supply is approximately 0.01% for a 30% change in line voltage. While this figure is more than adequate for the instrument when used in recommended fashion, it may cause some meter rattle if the linevoltage fluctuates badly while the instrument is used in the 0.01 Volt null range for metering excursions at several hundred Volts.

4-14 EFFECT OF AC COMPONENT. A two section low-pass filter (R74 and C21, R73 and C20) is used at the input to reduce any AC present on the DC being measured. If large AC components are present and the lowest null ranges must be used, external filtering may be required. If the AC is of a single frequency, a twin T filter is extremely effective and has the advantage of low total series resistance. If the AC is of variable frequency, an ordinary low-pass filter may be used. In either case the capacitors used should be high quality units of extremely high leakage resistance.

4-15 USE OF 0.1 VOLT AND 0.01 VOLT NULL RANGES. Use care when operating in the 0.1 and 0.01 Volt null ranges. Do not inadvertently apply several hundred Volts to the instrument with the RANGE switch set in the 0.5 Volt position as the chopper will be seriously overloaded. While the chopper used in the 8011A is an extremely rugged unit whose contacts are rated at 100 Volts maximum, repeated applications of several hundred Volts will have an adverse effect on it.

4-16 CIRCUIT DESCRIPTION

Figure 4-5 is a schematic of the 8011A circuitry. Figure 4-6 shows the physical location of important components.

The circuitry of the 8011A consists of six main elements:

a. A well regulated, extremely stable 500 Volt reference source.

b. Means for setting this reference source to 500 Volts within ±0.01%.

c. A range switch for dividing the 500 Volts down to three lower reference voltages of 50, 5, and 0.5 Volts.

d. A calibrated five decade Kelvin-Varley precision attenuator for dividing the reference voltage down to the exact level of the unknown voltage.

e. A calibrated VTVM which is used both as a conventional VTVM for determining the approximate value of the unknown voltage, and as a calibrated null detector for measuring the difference between the unknown voltage and the known voltage derived from the five decade calibrated attenuator.

f. Appropriate attenuators for limiting the VTVM input to 0.01 Volts maximum.

Element "a," the reference source, consists of an unregulated 680 Volt DC supply (CR1 thru CR3, C1 and C2), and a regulator delivering 500 Volts at 0.01% regulation (V1 thru V4 and associated components). This regulator consists of V4, a highly stable reference tube; V3, a balanced differential amplifier; V2, a drive amplifier; V1, a series passing tube; and R14 thru R18, a precision wirewound voltage sampling circuit. A simple transistor regulator, Q1 and Q2, stabilizes the heater voltage of V2 and V3 against line voltage fluctuations.

Element "b," the means for setting the reference source, consists of the CAL ADJ control (R18), the OPERATE-CAL switch (S2), and a Zener reference diode (CR9). A resistive divider of precision wirewound resistors, R25, R26, R27, and R28 across the diode divides its (approximate) 9.4 Volts down to exactly 8.5 Volts. Another divider made up of precision wirewound resistors R29, R30, and R31 divides the 500 Volt reference down to exactly 8.5 Volts. Withe the OPERATE-CAL switch in the CAL position the null detector is connected between the diode divider and the 500 Volt divider. The 500 Volt reference is adjusted for a null by means of the CAL ADJ control. This sets the reference supply to 500 Volts ±0.01%.

Element "c,", the RANGE switch, is comprised of switch sections S3B and S3C, precision wirewound resistors R32, R33, R38, R39, R40, R41, and R42, and variable resistors R35, R36, and R37.

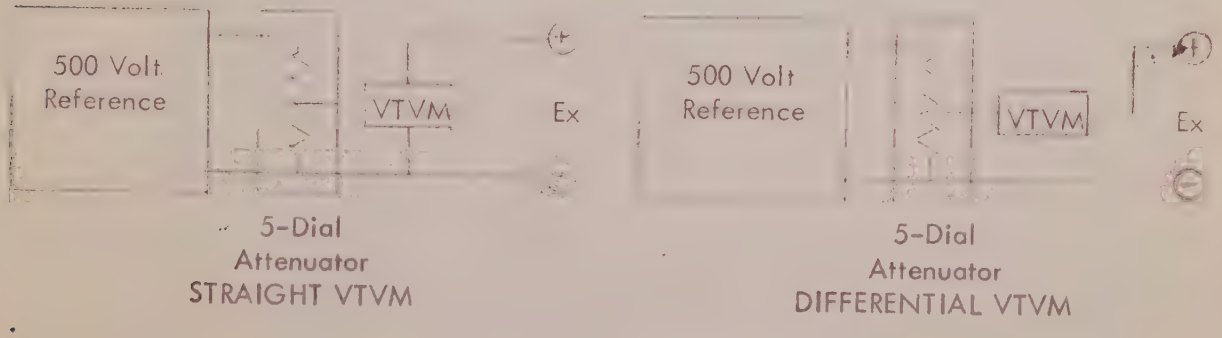
Element "d," the five-dial Kelvin-Varley attenuator, is made up of switches S5, S6, S7, S8, S9, and associated precision wirewound resistors R43, R44, R45, R46, and R47. The resistors on the A and B switches are matched to within ±0.0025%; those on the C, D, and E switches to within ±0.025%.

Element "e," the VTVM, consists of tubes V6 and V7, Chopper G1, meter M1, and associated components. The sensitivity of this VTVM is ±0.01 Volt input for full-scale deflection of the meter. The 0.01 Volt applied to the chopper is converted to a square wave which is amplified by V6 and V7. It is then rectified by the other chopper contact and filtered by a low-pass filter consisting of R58, R59, and C13. The DC current, which may be either positive or negative depending on the polarity of the input to the chopper, then drives the meter. Resistors R70 and R71 in series with the chopper reed provide feedback and eliminate the necessity for a zero control. A simple transistor regulator Q3 and Q4 stabilizes the heater voltage of V6 and V7 against line voltage fluctuations.

Element "f" consists of the appropriate sections of RANGE switch S3 and NULL switch S4, together with associated resistors R48 thru R52 and R75 thru R78, respectively. RANGE switch section S3E and resistors R48 thru R52 divide the unknown voltage down to 0.01 Volt from either 500, 50, or 5 Volts, depending on the setting of the switch.

In order to use the instrument as a straight VTVM, the negative input binding post is connected directly to the negative side of the voltmeter channel via NULL switch S4B; and the positive input binding post is connected to the VOLTS RANGE switch divider via NULL switch S4C. This is illustrated in the Block diagram below.

In order to use the instrument in the differential mode, the entire voltmeter channel is floated between the output of the five-dial attenuator and the positive input binding post. This is also illustrated in the block diagram below.



VTVM BLOCK DIAGRAM

This is effected by NULL switch sections S4A, S4B, and S4C. NULL switch section S4A also serves to attenuate the difference voltage to 0.01 Volts for application to the VTVM input. The difference voltage is applied directly to the VTVM without attenuation in the 0.01 Volt position of the NULL switch.

Capacitor C7 is a high grade polystyrene 1 mfd 100 Volt capacitor used to eliminate the hash picked up by the wirewound resistors in the five-dial attenuator, and to provide a return path to the negative binding post for the chopper input filter (C20, C21, R72, R73, and R74). Screwdriver adjustment R71 sets the gain of the VTVM so that 0.01 Volt input to the chopper gives full-scale deflection. This 0.01 Volt can come from the RANGE switch section S3E, NULL switch section S4A, or from the OPERATE-CAL switch when in the CAL position.

SECTION VI

TROUBLESHOOTING

TROUBLE	PROBABLE CAUSE	REMEDY
Meter offsets to left as voltage dial settings are increased.	Leakage from positive input terminal or null dividers to ground, caused by dampness or clinging dust and lint.	Dry out instrument, and blow out dust and lint with dry air.
Excessive drift or offset in meter, or failure of meter to read zero after warmup period	Faulty V5, V6, V7, or chopper (G1).	1. Place OPERATE-CAL switch in REF position. 2. The meter should read zero. 3. If not: a. Check V5. b. Check filament voltage and ripple (pin 4 or 5 of V6 to pin 3 of V7, 12.2 to 12.8 volts with ripple of 50 mv RMS or less, plus or minus 0.25 volts over operating range of 105 to 125 VAC.) c. Check B plus and ripple (pin 1 or 5 of V5, 142 to 157 volts with ripple of 100 mv RMS or less, plus or minus 1.5 volts over operating range of 105 to 125 VAC.) 4. If trouble persists: a. Check V6 and V7. b. Check chopper (G1) contacts by substituting a new chopper.

TROUBLE	PROBABLE CAUSE	REMEDY
Error in VTVM reading.	If the VTVM is off in all RANGE positions and all NULL positions the amplifier gain must be reset. If some ranges are accurate, the resistive dividers are out of tolerance.	1. If all ranges are off, check amplifier gain by applying a known ±10 millivolts to the instrument with the NULL switch in the 0.01 position and the five voltage dials at zero. This should give full-scale deflection. If not, adjust R71 for full-scale deflection. 2. If amplifier gain is set check the resistance dividers. R75 through R78 affect the NULL positions, while R48 through R52 affect the RANGE positions.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

MDI TA

T1 4 11 R1 100K VR1 JAN6CL6 V1 CR1 CR2 CR3 R80 560K C1 15 R2 22M R3 22M R4 10M R5 64K R6 76K R7 100K R8 560K R9 220K C4 .01 R10 150 C5 .1 R13 560K R14 195K R15 195K R16 76K R17 10K R18 1K V2 JRC5751 V3 JRC5751 V4 JRC5651WA C22 .01 R81 560K C23 .01 C2 15 C3 .1 R11 82K R12 220K Adj Cal R19 33K R20 33K R21 2.2K R22 270 R23 35K R24 44.5K R25 1K Zero adjust set Reference R26 50 R27 1350 R28 17K R29 125K R30 125K R31 4323.5 R32 112.375K R33 112.375 .5V 50V 500V R34 27K R35 750 R36 750 R37 750 R38 22.5K R39 24.75K R40 28.571K R41 2531.7 R42 250.31 S3B S3C Range Switch R43 240K R44 88K R45 17.6K R46 3520 R47 640 S5 S6 S7 S8 S9 R48 180K D.C. R49 18K D.C. R50 1.8K D.C. R51 200 D.C. R52 9.8M D.C. S3E C6 .68 C7 1.0 C8 .68 Range Switch S3D R79 270 R78 9M D.C. R77 900K D.C. R76 90K D.C. R75 10K D.C. S4A S4B S4C

F1 S1 2 F2 3 HR1 HR2 S10 OVEN A C B J1

CR5 8 C9 2000 JAN2N331 SIG-C-2N297A V2 V3 CR9 OVEN

CR6 CR7 CR8 R53 1K R54 2.7K R55 10K 1,5 JRC0A2WA V5 C10A 40 C10B 40 R56 33K R57 3.0K C11 2000 SIG-C-2N297A V6 V7 R63 180K

R64 560K R65 68K JRC6AU6WB V7 C19 .033 R72 1M R73 1M R74 1M G1 VR2 S2A S2B S4B Adj Ref Operate

C12 4 R60 39K C14 .033 C15 .033 V6 JRC5751 R58 5.6K C13 100 R61 390 R62 1.8M R66 560 R67 1.8M C17 4 C16 .005 R68 1200 C18 100 R69 2.2M R70 71.5 TRIM GAIN R71 25 C20 .1 C21 .1

R59 5.6K M1 (100-0-100UA)

16 DS1 G1 S3A Range Switch DS2 DS3 DS4 DS5

DRAWN	WRP 2-2-61
CHECKED	2-4-61
APPROVED	
NOTE:	

SCHEMATIC

JOHN FLUKE MFG CO., INC.
MOUNTLAKE TERRACE, WASH

8011A-102

SCALE: NONE | CODE

MP MASTER
MA32794